

Measuring Water Quality Improvement Due to BMP Implementation in Four Oklahoma Watersheds

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Key Points

- Description of projects and the BMP implementation in four high priority watersheds
- Comparison of water quality improvements observed using the paired watershed design and analysis procedures
- Discussion of how the results differed through time, and how much monitoring is necessary to detect water quality improvements over a long period
- General lessons learned from these projects that are applicable to other programs



By state statute, the OCC serves as the technical lead agency of Oklahoma's Nonpoint Source (NPS) Program.

This responsibility means monitoring and assessing waterbodies for NPS impacts and implementing programs to reduce these NPS issues, with the ultimate goal of restoring full support of the designated uses of all waterbodies.

Implementation Projects

- **Spavinaw Creek** (Project Timeline = 2003-2015)
- **Honey Creek** (Project Timeline = 2006-2012)
- **Illinois River** (Project Timeline = 2007-2015)
- **North Canadian River** (Project Timeline = 2006-2015)




Data Analysis: Paired Watershed Method

- Two watersheds:
Control (no BMPs) = upstream
Treatment (BMPs installed) = downstream
 - Watersheds should be similar size, slope, location, soils and land cover/use
 - Must establish a relationship between the watersheds for each parameter; does not require same water quality
 - Control accounts for year-to-year and seasonal climate variations
- Two periods of study:
Calibration (pre-BMP installation)
Treatment (during or post-implementation)

United States
Environmental Protection
Agency

Office of Water
Washington, D.C. 20460

841-F-93-009
September 1993

 **EPA**

**Paired Watershed
Study Design**

INTRODUCTION

The purpose of this fact sheet is to describe the paired watershed approach for conducting nonpoint source (NPS) water quality studies. The basic approach requires a minimum of two watersheds - control and treatment - and two periods of study - calibration and treatment. The control watershed accounts for year-to-year or seasonal climate variations, and the management practices remain the same during the study. The treatment watershed has a change in management at some point during the study. During the calibration period, the two watersheds are treated identically and paired water quality data are collected (Table 1). Such paired data could be annual means or totals, or for shorter studies (<5 yr), the observations could be seasonal, monthly, weekly, or event-based. During the treatment period, one watershed is treated with a best management practice (BMP) while the control watershed remains in the original management (Table 1). The treated watershed should be selected randomly by such means as a coin toss. The reverse of this schedule is possible for certain BMPs; the treatment period could precede the calibration period. For example, the study could begin with two watersheds in two different treatments, such as "BMP" and "no BMP". Later both watersheds could be managed identically to calibrate them. Since no calibration exists before the treatment occurs, this reversed design is considered risky.

Table 1. Schedule of BMP implementation.

Period	Watershed	
	Control	Treated
Calibration	no BMP	no BMP
Treatment	no BMP	BMP

The basis of the paired watershed approach is that there is a quantifiable relationship between paired water quality data for the two watersheds, and that this relationship is valid until a major change is made in one of the watersheds. At that time, a new relationship will exist. This basis does not require that the quality of runoff be statistically the same for the two watersheds; but rather that the relationship between paired observations of water quality remains the same over time except for the influence of the BMP. Often, in fact, the analysis of paired observations indicates that the water quality is different between the paired watersheds. This difference further substantiates the need to use a paired watershed approach because the technique does not assume that the two watersheds are the same; it does assume that the two watersheds respond in a predictable manner together.

EXAMPLE
To illustrate the paired watershed approach, data taken from a study in Vermont will be used. The purpose of the study was to compare changes in field runoff (cm) due to conversion of conventional tillage to conservation tillage.

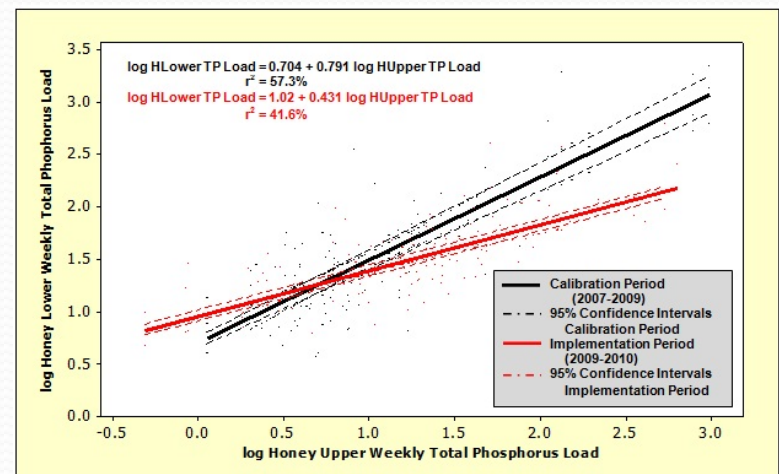
EPA method 841-F-93-009 developed
by J.C. Clausen and J. Spooner 1993

Data Analysis: Paired Watershed Method

- Perform ANCOVA to analyze difference between periods while accounting for environmental effects
- Determine load reductions by comparing “expected” loads to “monitored” loads during treatment period

Expected loads are modeled loads based upon the calibration period relationship

(Indicates what the loads should be in the treatment watershed if nothing changed from calibration period)



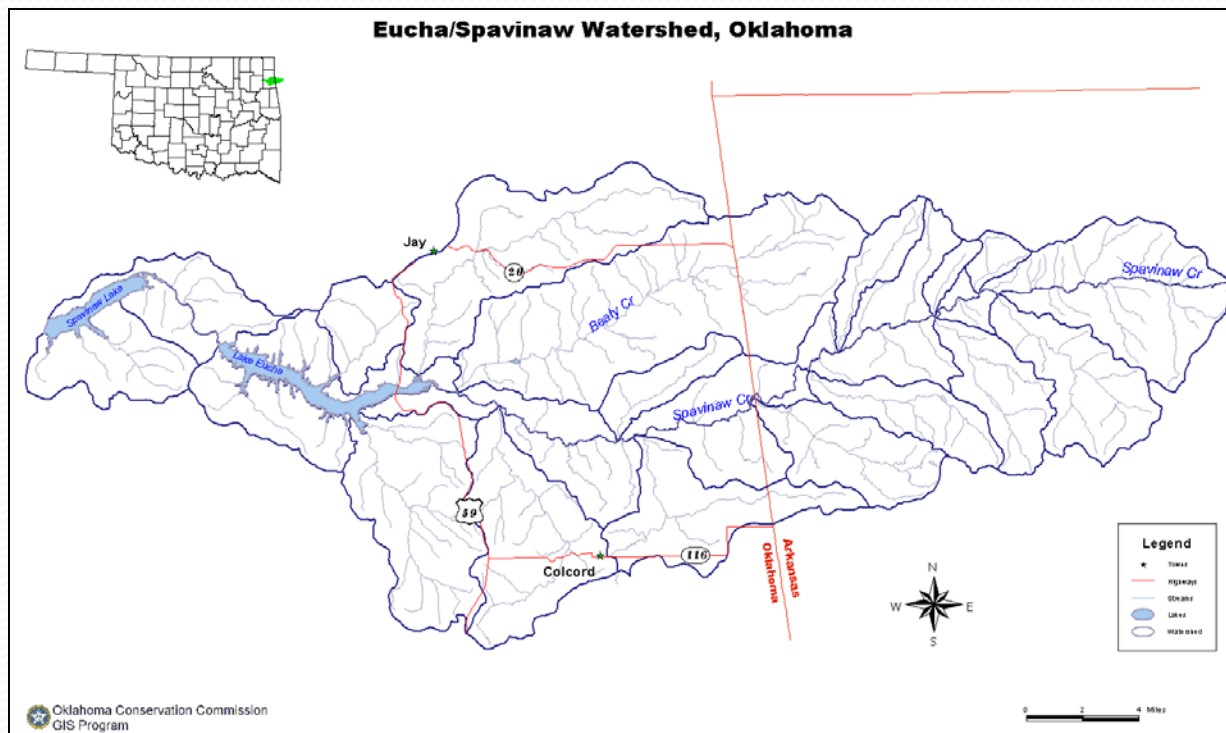
Monitoring Design

- Continuous, flow-weighted composite sampling
 - Total Phosphorus, orthoPhosphorus, nitrate, ammonia, Total Kjeldahl Nitrogen (weekly and storm events)
- Field parameters
 - DO, pH, temperature, conductivity, hardness, alkalinity, turbidity & flow (weekly)
- Weekly grabs for bacteria (May-September)
- Monthly grabs for total suspended solids, chloride, sulfate
- Biological
 - Fish (biannually)
 - Habitat (biannually)
 - Macroinvertebrates (twice yearly)



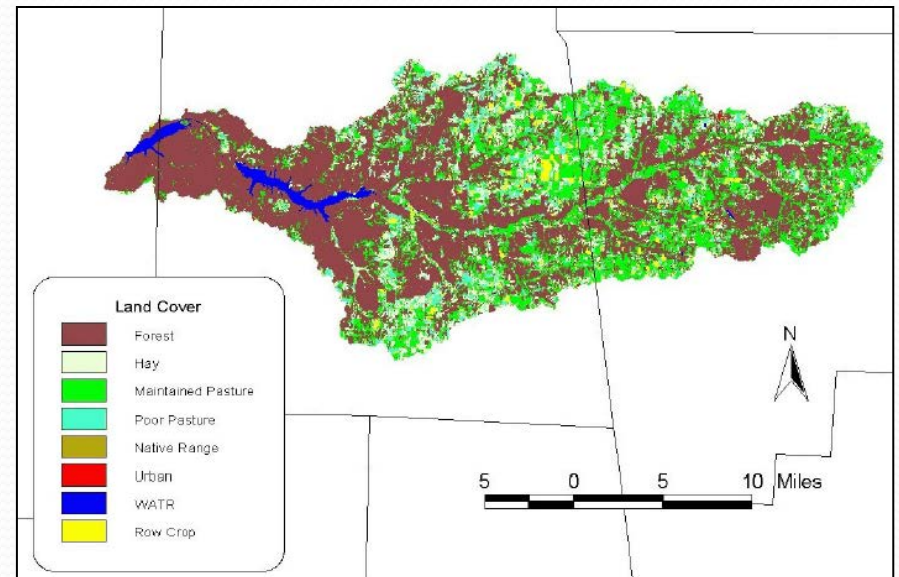
Spavinaw Creek

- Watershed = 230,000 acres in Arkansas & Oklahoma (60% in Oklahoma)
- Lakes Eucha and Spavinaw provide water for a combined population of nearly one million people in northeastern Oklahoma



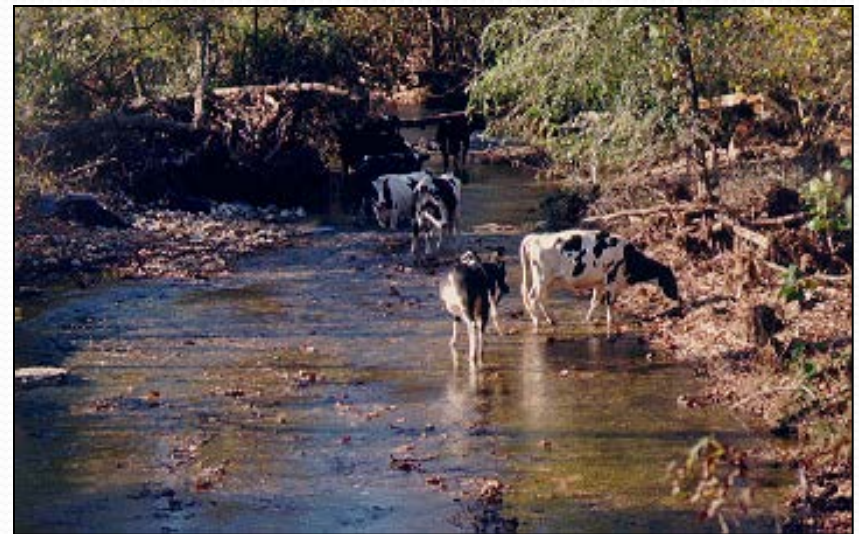
Landuse in Spavinaw Creek Watershed

- 52 % forested
- 23 % well managed pastures
- 13 % hayed pastures
- 7 % poorly managed pastures
- 3 % row crop
- 1 % urban
- 1 % brushy rangeland



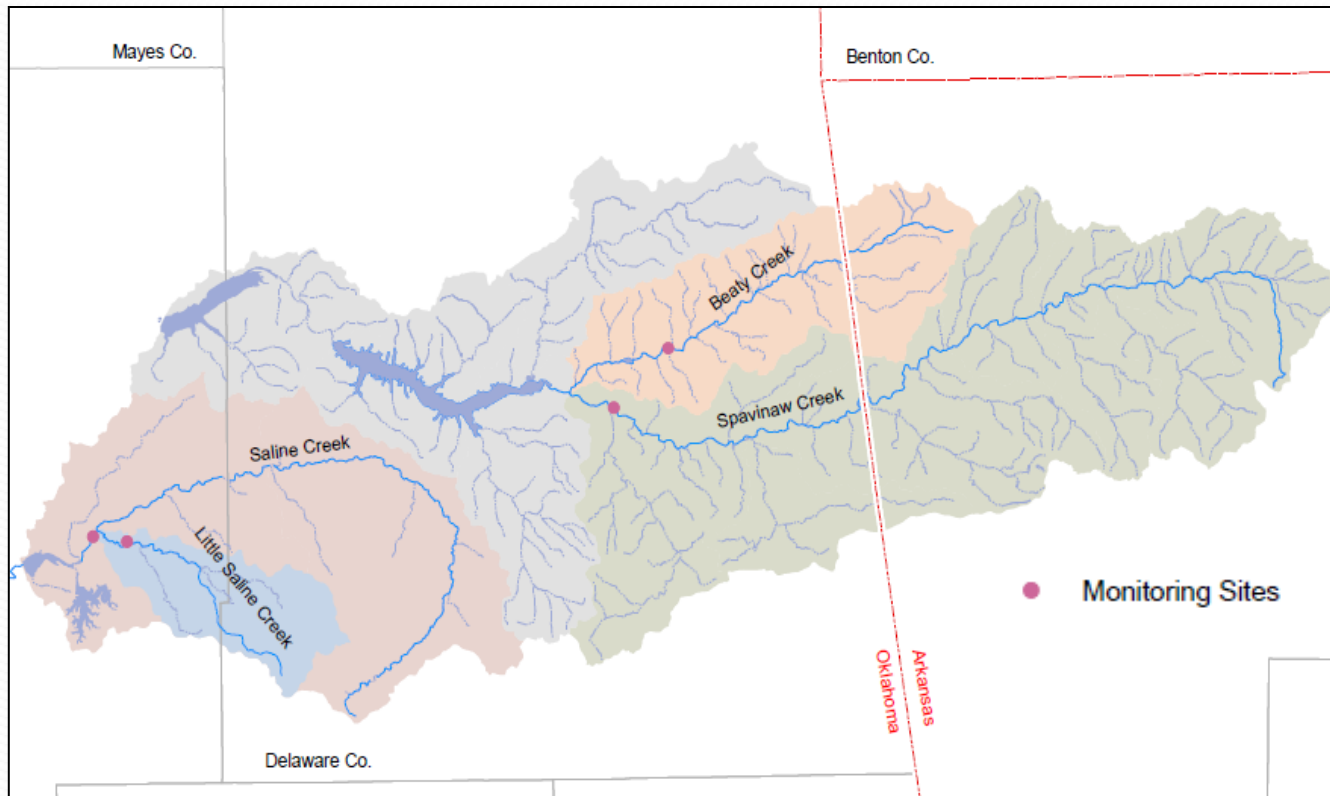
Agriculture Activities in Spavinaw Creek Watershed

- Significant poultry production
 - capacity to produce 77 million birds annually;
> 73,000 tons of litter produced annually
- Strong beef cattle production; dairy and hog farms also present
- Poor/nonexistent riparian areas
 - Removal of vegetation and uncontrolled livestock access
 - Significant streambank erosion and habitat loss



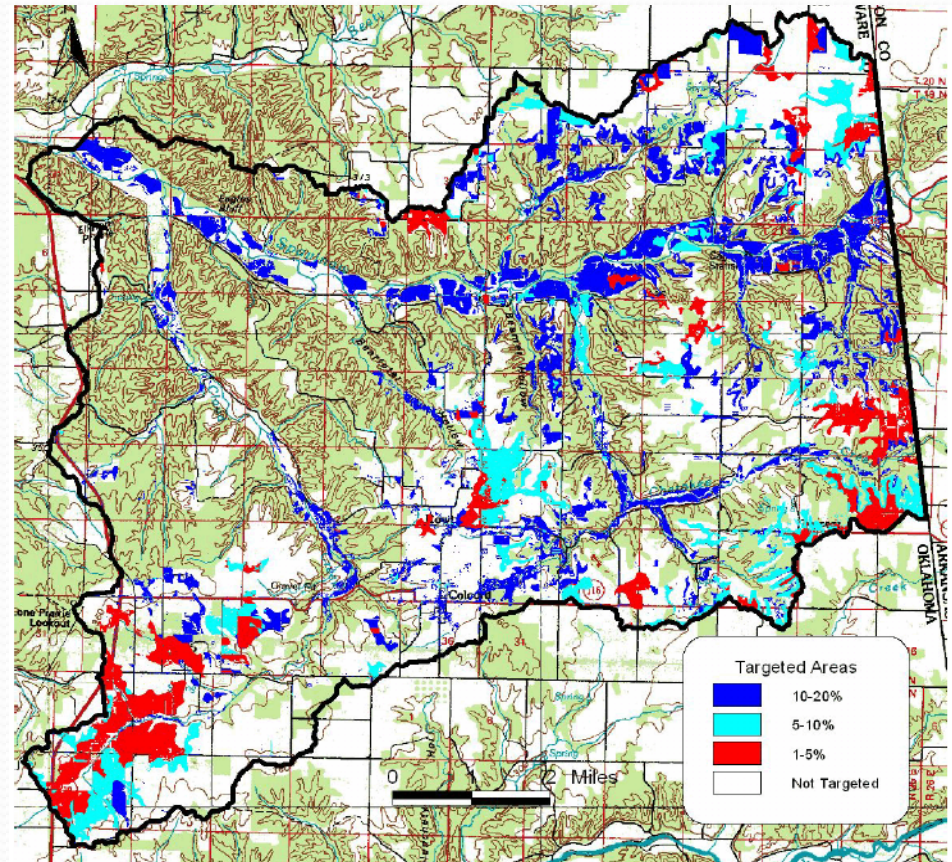
Spavinaw Creek Monitoring Design

- 4 Autosamplers
- Little Saline Creek (control) vs. Beaty Creek (treatment)
- Saline Creek (control) vs. Spavinaw Creek (treatment)



Spavinaw Creek Monitoring Design

- Able to target BMP practices towards the most significant sources in “hotspot” areas based on SWAT (Soil & Watershed Assessment Tool) modeling.



Spavinaw Creek BMP Implementation

- Riparian area establishment/management & buffer zone/filter strip establishment
- Streambank stabilization
- Composter/animal waste storage facilities
- Proper waste/litter utilization
- Pasture establishment/improvement/management
- Heavy use areas
- Rural waste systems



Spavinaw Creek BMP Implementation

\$319 Water Quality Implementation Project in the Lake Eucha- Spavinaw Creek Watershed

Cost Share Available for the
following Best Management
Practices (BMPs):

- Cross Fence
(80% of \$1.80/ ft)
- Replacement of Septic
Systems
(80% of Actual Cost)
- Well & Pump
(80% of \$19.04/ft)
- Watering Tanks
(80% of \$34.19/gallon)
- Heavy Use Area
(75% of \$41.69/cubic
yard, gravel & fiber)
- Pipeline
(80% of \$1.46/ ft)
- Riparian Fence
(80% of \$2.40/ft)
- Pasture Planting
(80% depends on type)
- Pond
(80% of \$1.94/cubic

Target Area for Implementation of BMPs:



For More Information, Contact:

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Responsible Care for Oklahoma's Natural Resources

Spavinaw Creek Results

- 2008-2011

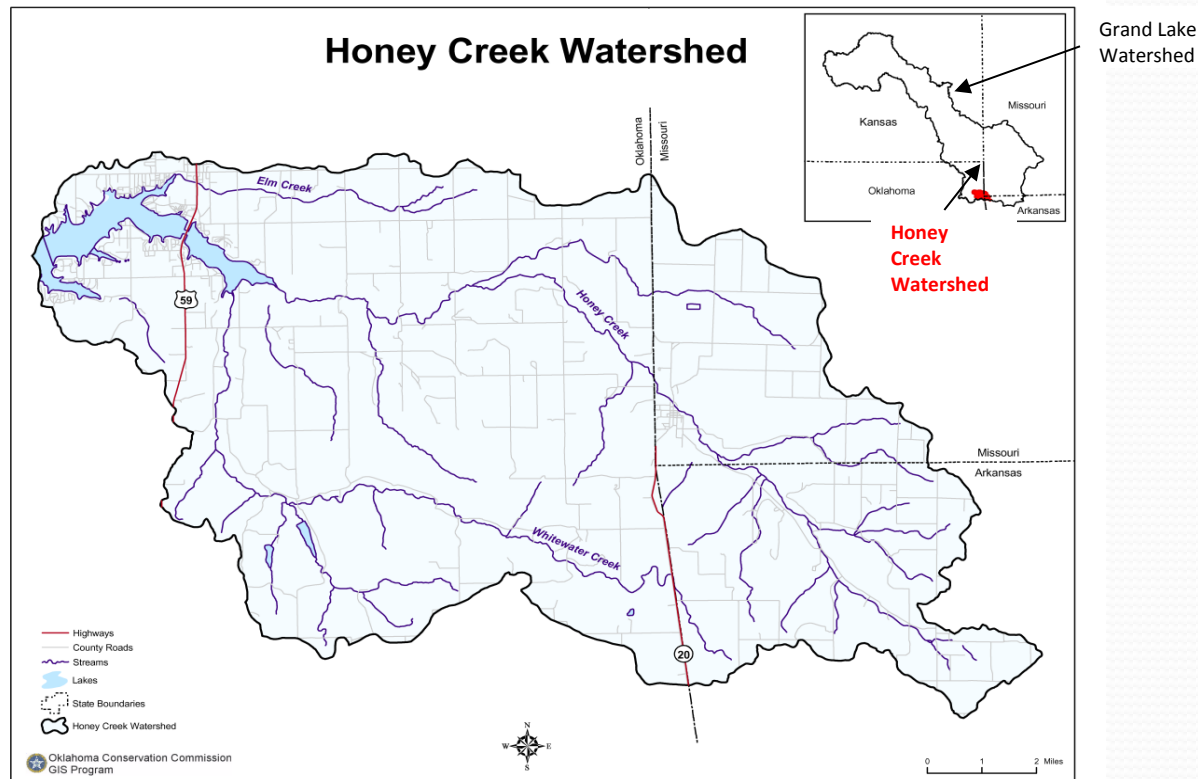
- Total Phosphorus load reduction = 37%
- OrthoPhosphorus load reduction = 64%
- Ammonia load reduction = 19%
- Nitrate load reduction = 46%

- 2012-2015

- Results currently being analyzed

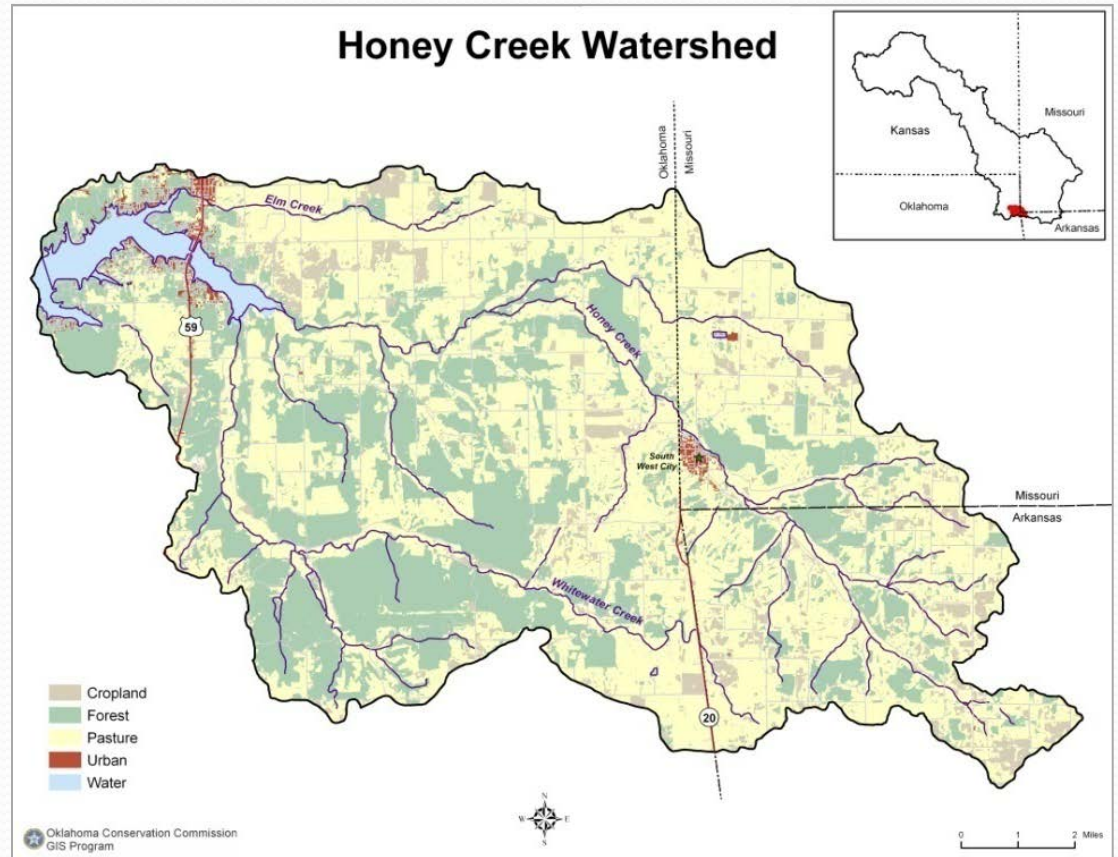
Honey Creek

- Honey Creek is a tributary to Grand Lake in northeastern Oklahoma
- 78,000 acre watershed in 3 states (70% in OK)



Landuse in Honey Creek Watershed

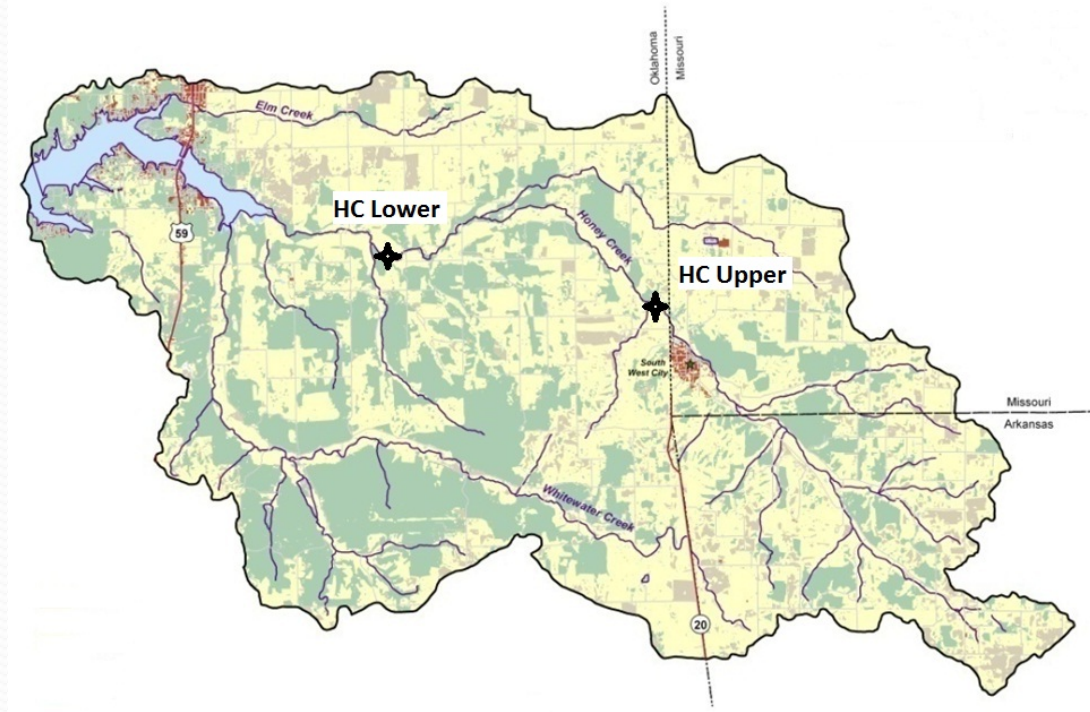
- 60% pastureland
- 33% forest
- 7% cropland



Approximately **1.5 million** chickens produced each year in Delaware County (2010 AG census)

Honey Creek Monitoring Design

- 2 Autosamplers
- Honey Creek: Upper (control) vs. Honey Creek: Lower (treatment)



Honey Creek BMP Implementation

- Pasture establishment and management (planting and cross fencing)
- Riparian area establishment and management
- Alternative water supplies
- Animal waste storage/feeding facilities
- Heavy use area protection
- Poultry litter transport



Honey Creek Results

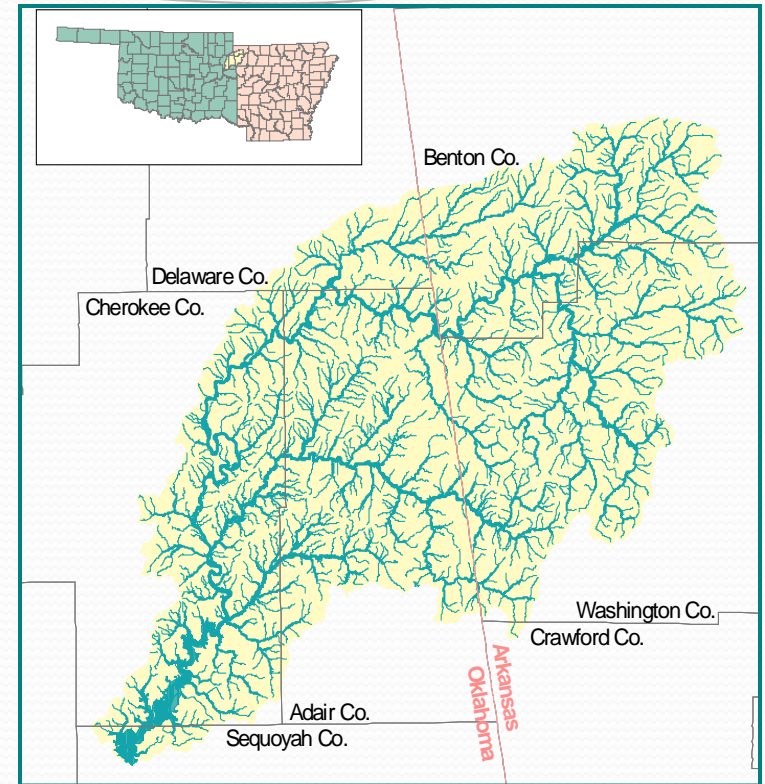
- Total Phosphorus load reduction = 28%
- Nitrate load reduction = 35%
- *E. Coli* load reduction = 34%

Special note: Both segments of Honey Creek have now been delisted for *E. Coli*



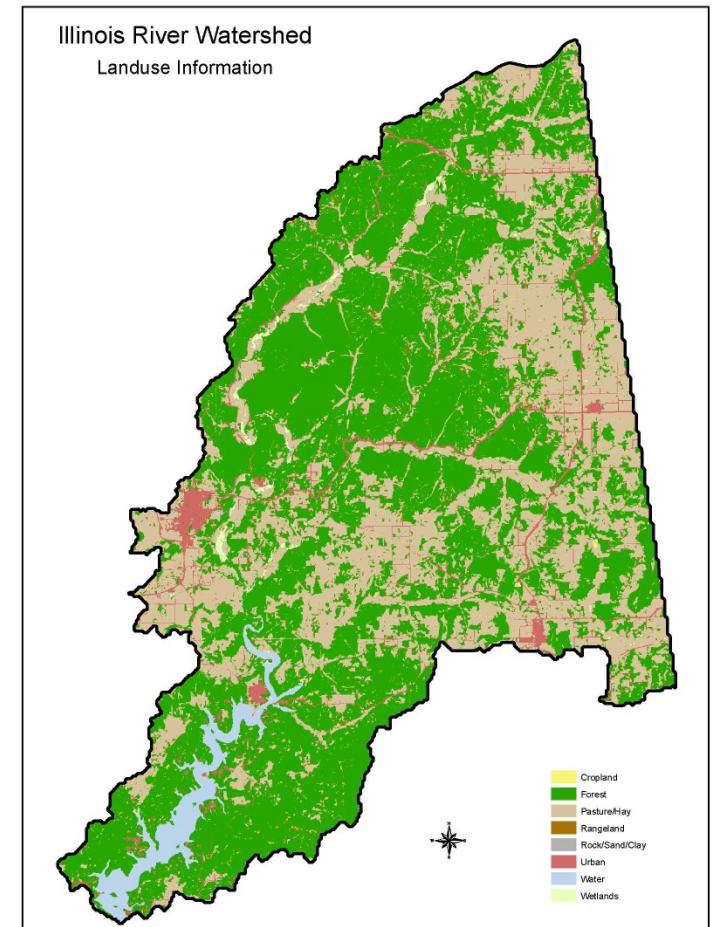
Illinois River

- One of Oklahoma's highest priority watersheds
- Watershed = 1,069,530 acres (54% in Oklahoma)
- The major tributaries of the Illinois River in Oklahoma are the Baron Fork River, Caney Creek, and Flint Creek. Lake Tenkiller is the major reservoir that receives the Illinois River. The Illinois River, Baron Fork, and Flint Creek are classified as state scenic rivers, and they support a very large recreational industry including canoeing, rafting, and camping



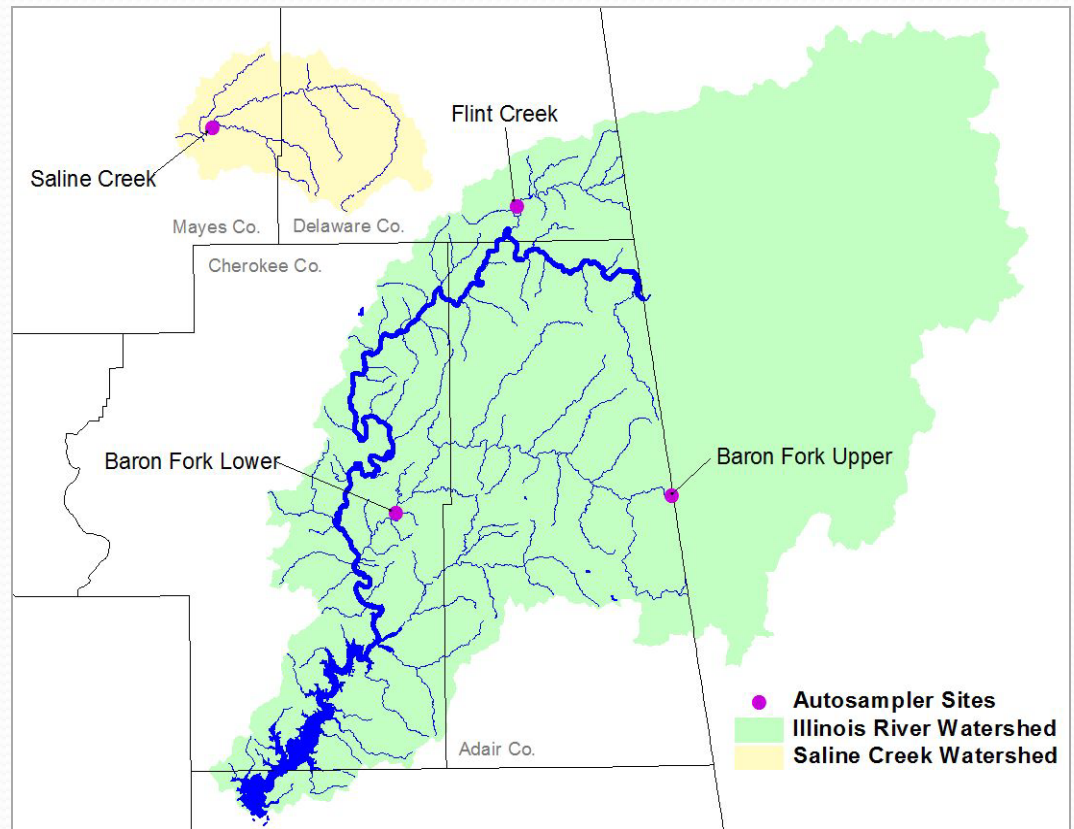
Landuse in Illinois River Watershed

- Land cover in the Oklahoma portion of the Illinois River Basin:
 - 46 % forest
 - 15 % hay
 - 24 % well-managed pasture
 - 8 % poorly managed pasture
 - 1 % rangeland
 - 3 % urban
 - 2 % water
 - 1 % row crops/small grains



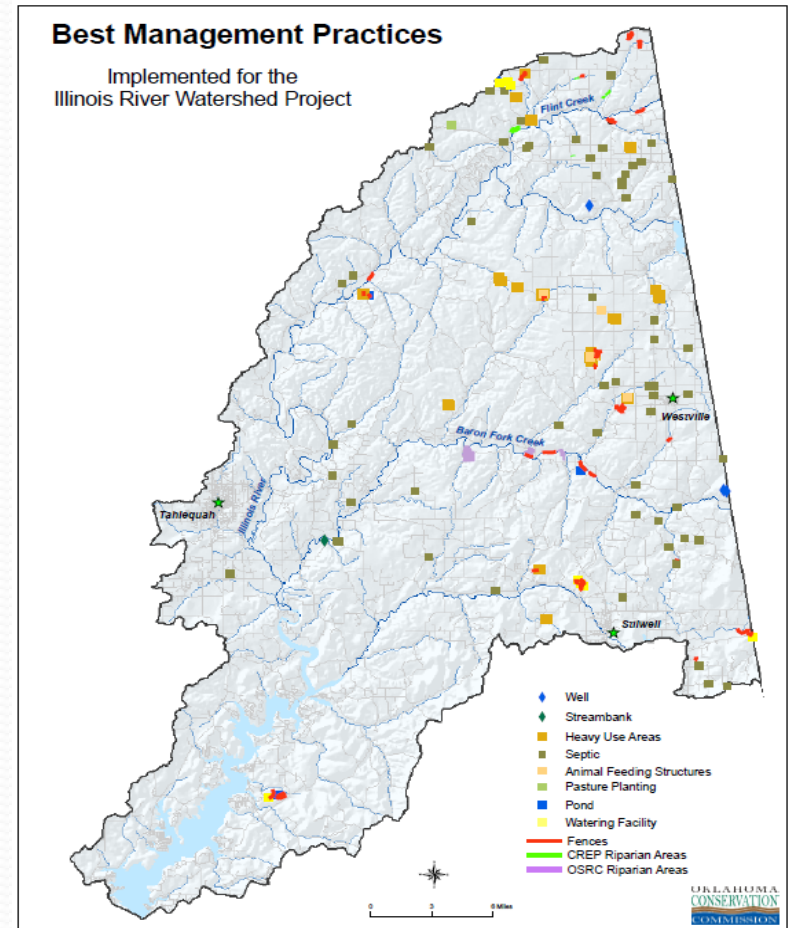
Illinois River Monitoring Design

- 4 Autosamplers
- Baron Fork Creek: Upper (control) vs. Baron Fork Creek: Lower (treatment)
- Saline Creek (control) vs. Flint Creek (treatment)



Illinois River BMP Implementation

- Riparian area establishment and management
- Buffer strip establishment and streambank protection
- Animal waste management
- Proper waste utilization (poultry waste producers)
- Heavy use areas
- Rural waste septic systems



Illinois River Results



- Flint Creek Watershed:

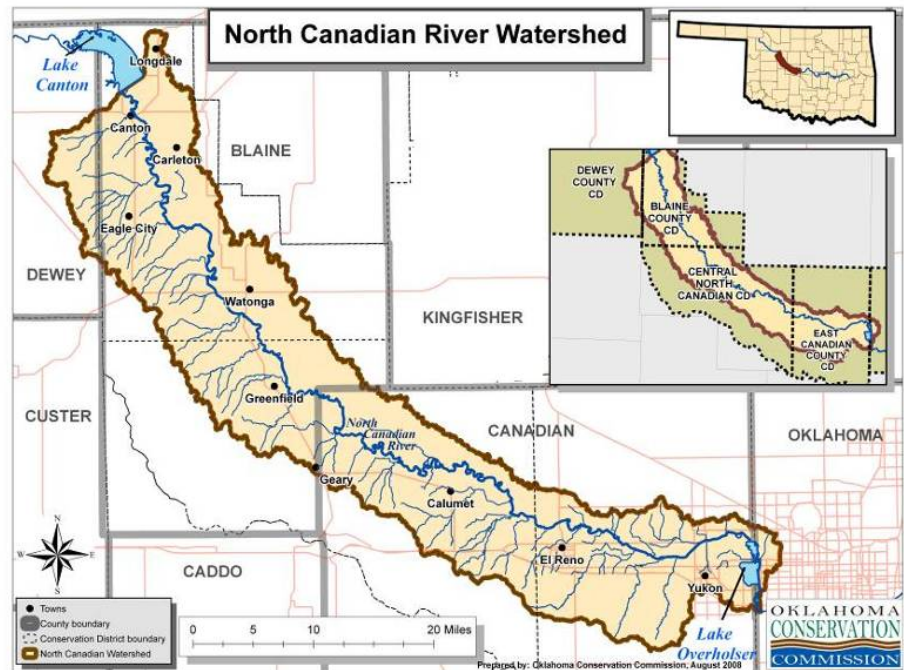
- Total Phosphorus load reduction = **30%**
- OrthoPhosphorus load reduction = **54%**
- Nitrate load reduction = **60%**
- E.coli load reduction = **41%**

- Baron Fork Creek Watershed:

- OrthoPhosphorus load reduction = **15%**
- Nitrate load reduction = **47%**
- Ammonia load reduction = **20%**

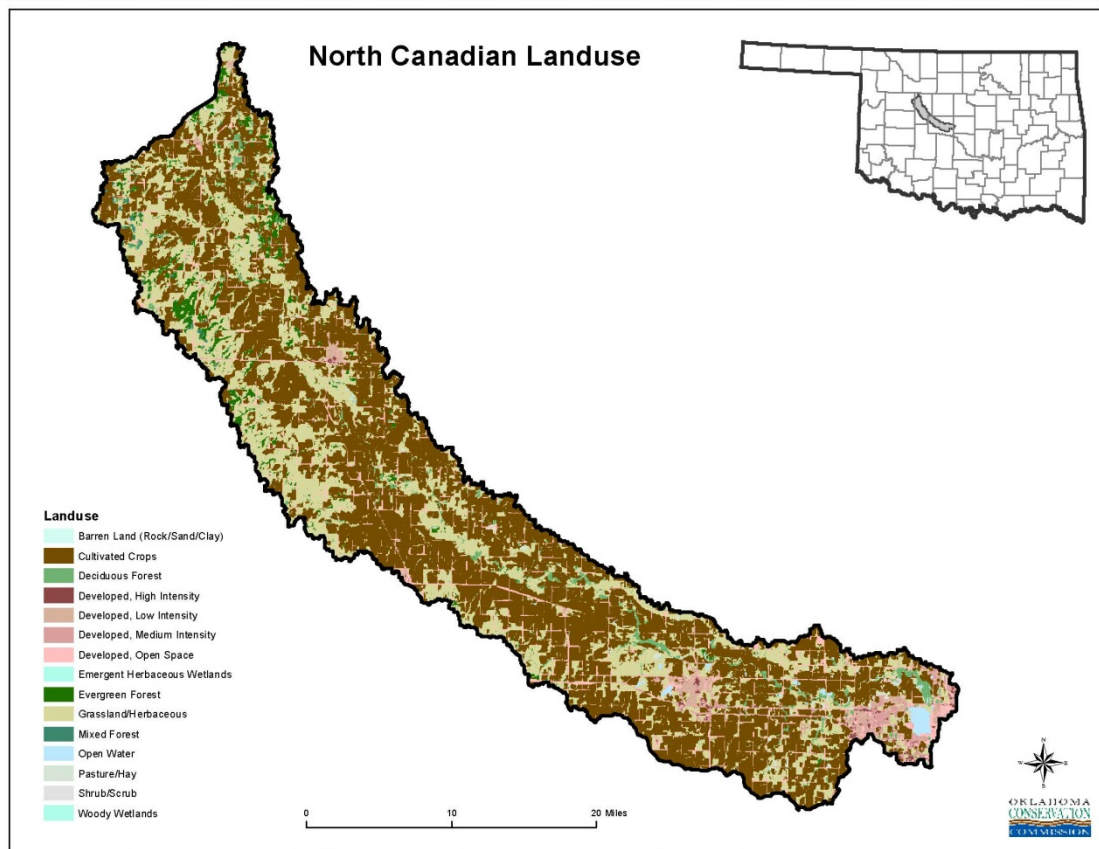
North Canadian River

- Watershed = 48,4815 acres
- Landuse is primarily agricultural
- Erosion is significant factor
- Most soils in the watershed are highly erodible sandy, silty, or clay loams



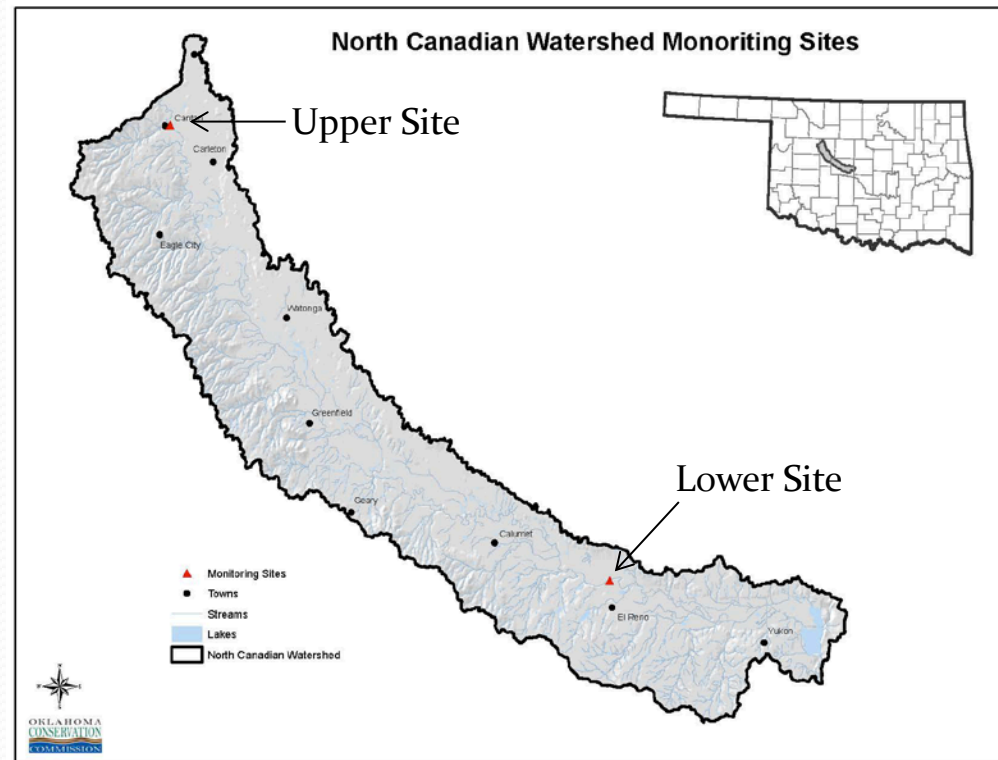
Landuse in North Canadian River Watershed

- 42 % small grains (wheat, rye, sorghum)
- 20% Grasslands
- 13 % row crops (cotton, soybeans, peanuts)
- 11 % pasture/hay
- 6 % forest
- 3 % residential
- 3 % shrubland
- 2 % open water



North Canadian River Monitoring Design

- 2 Autosamplers
- North Canadian River: Upper (control) vs. North Canadian River: Lower (treatment)



North Canadian River BMP Implementation

- **Erosion control**
- Conversion from conventional tillage to No-till farming
- Riparian area buffer zones
- Livestock management
- Septic systems



North Canadian River Results

- Total Phosphorus load reduction = 75%
- OrthoPhosphorus load reduction = 87%
- TKN load reduction = 66%
- Nitrate load reduction = 75%
- *E. Coli* load reduction = 44%
- Turbidity load reduction = 27%

Note: These results are preliminary; we are continuing to analyze for autocorrelation.

How results differed through time

- Shorter term data might tell you that you're on the right track with your efforts, but not necessarily what the long-term impacts of those will be.
 - In Honey Creek, after 3 years we saw a statistically significant decrease in TP loading of 15%, after 6 years it was 28%
 - 10+ years is best

Lessons Learned

- BMP implementation success is vital for NPS programs
- You can never spend too much money on the monitoring component
- Talk about successes at every opportunity you have
- Continue to find opportunities for local groups to be involved in the process

Lessons Learned

- Autosamplers require more time & energy than one would expect from the word “autosampler”



High Flow & Miscellaneous

- Expect some problems with & anger towards the autosamplers



(Surprisingly, it was not OCC monitoring staff who shot this unit)

High Flow, continued...



Partnership!



United States Department of Agriculture
Natural Resources Conservation Service



Local citizens



Oklahoma Association
of
Conservation Districts





Questions?

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